FOREWORD

Purpose

This manual was prepared by Project Delivery, Division of Design. The manual establishes uniform policies and procedures to carry out the highway design functions of the California Department of Transportation (Caltrans). It is neither intended as, nor does it establish, a legal standard for these functions.

The policies established herein are for the information and guidance of the officers and employees of the Department.

Many of the instructions given herein are subject to amendment as conditions and experience seem to warrant. Special situations may call for variation from policies and procedures, subject to Division of Design approval, or such other approval as may be specifically provided for.

It is not intended that any standard of conduct or duty toward the public shall be created or imposed by the publication of this manual. Statements as to the duties and responsibilities of any given classification of officers or employees mentioned herein refer solely to duties or responsibilities owed by those in such classification to their superiors. However, in their official contacts, each employee should recognize the necessity for good relations with the public.

Scope

This manual is not a textbook or a substitute for engineering knowledge, experience, or judgment. It includes techniques as well as graphs and tables not ordinarily found in textbooks. These are intended as aids in the quick solution of field and office problems. Except for new developments, no attempt is made to detail basic engineering techniques; for these, standard textbooks should be used.

Form

The loose-leaf form was chosen because it facilitates change and expansion. New instructions will be issued as sheets in the format of this manual; these may consist of additional sheets or new sheets to be substituted for those superseded.

Organization of the Manual

A decimal numbering system is used which permits identification by chapter, topic, and index, each of which is a subdivision of the preceding classification. For example:

Chapter 40 Federal-aid

Topic 42 Federal-aid System

Index 42.2 Interstate

The upper corner of each page shows the page number and the date of issue.

Use of the Table of Contents

The Table of Contents gives the index number and page number for each topical paragraph together with corresponding dates of issue. The holder of the manual should insert the title and the appropriate dates of new instructions as they are received. Revised Table of Contents will be issued as the need arises.

Use of the English and Metric Editions of the Highway Design Manual

This Fifth Edition of the Highway Design Manual is in metric units. All previous English editions are now obsolete and no longer reflect current standards. Standard specifications, Special Provisions, and Standard Plans no longer support English unit standards. All projects will be designed and constructed in metric units following the standards in this manual per the instructions contained in Index 82.5, “Effective Date for Implementing Revisions to Design Standards”. Projects designed and constructed in English units must be designed and constructed in accordance with Chief Engineer, Brent Felker's, memorandum "Processing English Unit Projects", dated April 21, 2000. Encroachment projects up to $1,000,000 in State Right of Way, may be submitted in dual units, in accordance with Robert L. Buckley's memorandum "Dual Units on Encroachment Permit Projects", dated October 22, 1999.

Metric Basics

Measurable Attribute - Basic Units	Unit	Expression
Length	meter	m
Mass	kilogram	kg
Luminous intensity	candela	cd
Time	second	s
Time	hour	h
Electric current	ampere	A
Thermodynamic temperature	Kelvin	K
Amount of substance	mole	mol
Volume of liquid	liter	L

Measurable Attribute - Special Names	Unit	Expression
Frequency of a periodic phenomenon	hertz	Hz (1/s)
Force	newton	N ($kg \cdot m/s^2$)
Energy/work/quantity of heat	joule	J($N \cdot m$)
Power	watt	W (J/s)
Pressure/stress	pascal	Pa (N/m^2)
Celcius temperature	Celsius	°C
Quantity of electricity/electrical charge	coulomb	C
Electric potential	volt	V
Electric resistance	ohm	Ω
Luminous flux	lumen	lm
Luminance	lux	lx (lm/m^2) or (cd/m^2)

Measurable Attribute - Derived Units	Unit	Expression
Acceleration	meter per second squared	m/s^2
Area	square meter	m^2
Area	hectare	ha (10 000 m^2)
Density/mass	kilogram per cubic meter	kg/m^3
Volume	cubic meters	m^3
Velocity	meter per second	m/s
Mass	tonne	tonne (1000 kg)

Multiplication Factors	Prefix	Symbol	Pronunciations
1 000 000 000 = 10^9	giga	G	jig' a (*i* as in j*i*g, *a* as in *a*-bout)
1 000 000 = 10^6	mega	M	as in *mega*-phone
1000 = 10^3	kilo	k	kill' oh
100 = 10^2	*hecto	h	heck' toe
10 = 10^1	*deko	da	deck' a (*a* as in *a*-bout)
0.1 = 10^{-1}	*deci	d	as in *deci*-mal
0.01 = 10^{-2}	*centi	c	as in *centi*-pede
0.001 = 10^{-3}	milli	m	as in *mili*-tary
0.000 001 = 10^{-6}	micro	μ	as in *micro*-phone
0.000 000 001 = 10^{-9}	nano	n	nan' oh (*an* as in *ant*)

* to be avoided where possible

Common Conversion Factors to Metric

Class	Multiply:	By:	To Get:
Area	ft^2	0.0929	m^2
	yd^2	0.8361	m^2
	mi^2	2.590	km^2
	acre	0.404 69	ha
Length	ft	0.3048	m
	in	25.4	mm
	mi	1.6093	km
	yd	0.9144	m
Volume	ft^3	0.0283	m^3
	gal	3.785	L *
	fl oz	29.574	mL *
	yd^3	0.7646	m^3
	acre ft	1233.49	m^3
Mass	oz	28.35	g
	lb	0.4536	kg
	kip (1,000 lb)	0.4536	tonne (1000 kg)
	short ton (2,000 lb)	907.2	kg
	short ton	0.9072	tonne (1000 kg)
Density	lb/yd^3	0.5933	kg/m^3
	lb/ft^3	16.0185	kg/m^3
Pressure	psi	6894.8	Pa
	ksi	6.8948	MPa (N/mm^2)
	lb_f/ft^2	47.88	Pa
Velocity	ft/s	0.3048	m/s
	mph	0.4470	m/s
	mph	1.6093	km/h
Temp	°F	$t\,°_C = (t\,°_f - 32)/1.8$	°C
Light	footcandle (or) lumen/ft^2	10.7639	lux (lx) (or) lumen/m^2

* Use Capital "L" for liter to eliminate confusion with the numeral "1"

Land Surveying Conversion Factors

Class	Multiply :	By:	To Get
Area	acre	4046.87261	m^2
	acre	0.404 69	ha (10 000 m^2)
Length	ft	1200/3937**	m

** Exact, by definition of the US Survey foot, Section